PROCEEDINGS

OF

THE ROYAL SOCIETY.

1830–1831. No. 2.

December 23.

JOHN W. LUBBOCK, Esq. V.P. and Treasurer, in the Chair.

James Smith, Esq. of Jordan Hill, Glasgow, was elected a Fellow of the Society.

The following Presents were received, and thanks ordered for them:—

Chemical Manipulation, being instructions to Students in Chemistry on the methods of performing Experiments of demonstration or of research with accuracy and success. New edition. By Michael Faraday, Esq. F.R.S. 8vo.—*Presented by the Author.*

Experimental Inquiries on Electrical Accumulation. By Wm. Snow Harris, Esq. 8vo.—*The Author.*

On the Utility of Fixing Lightning Conductors in Ships. By W. S. Harris, Esq. 8vo.—*The Author.*

Observationes Astronomicæ in Speculâ Universitatis Litterariæ Fennicæ factæ. Tomus I. Aboæ A. A. 1824, 1825. Universitatis nomine instituit Mag. Fredr. Guil. Aug. Argelander. folio.—*Professor Argelander.*

Astronomische Beobachtungen auf des Herrn Capitain Otto v. Kotzebue zweiten Reise um die Welt in den Landungsplätzen angestellt von E. W. Preuss. Herausgegeben von W. Struve. 4to.—*Professor Struve, Foreign Memb. R.S.*

Recueil de Lectures faites dans la Séance Publique Annuelle de l'Institut Royal de France, du mardi 24 Avril 1827. 4to.—*The Institute.*

Analyse des Travaux de l'Académie Royale des Sciences, pendant l'Année 1828. Partie Mathématique. Par M. le Baron Fourier, Secrétaire Perpétuel. 4to.—*The Academy.*

——————————— Partie Physique. Par M. le baron Cuvier, Secrétaire Perpétuel. 4to.—*The Academy.*

Exposé des Recherches faites par ordre de l'Académie Royale des Sciences, pour determiner les Forces Elastiques de la Vapeur d'Eau à de Hautes Températures. (Par MM. Prony, Arago, Girard, et Dulong.) 4to.—*The Academy.*

Rapport fait à l'Académie Royale des Sciences, par MM. Thenard et Chevreul, sur un Mémoire de M. Férullas, ayant pour titre: *De l'Action de l'Acide sulfurique sur l'alcohol et des produits qui en résultent;* imprimé par ordre de l'Académie. 4to.—*The Academy.*

Rapport sur le Prix de Statistique (décerné à l'ouvrage de M. Falret, sur les aliénés, les suicides, et les morts subites). 4to.—*The Academy.*

Eloge Historique de L. F. E. Baron Ramond. Par M. le baron Cuvier. 4to.—*The Academy.*

Eloge Historique de M. Bosc. Par M. le baron Cuvier. 4to.—*The Academy.*

Discours de M. Féletz, Chancelier, prononcé aux Funérailles de M. le baron Fourier. 4to.—*The Academy.*

Discours de M. Girard, Président de l'Académie des Sciences, prononcé aux Funérailles de M. le baron Fourier. 4to.—*The Academy.*

Mémoire Physiologique sur le Cerveau. Par M. Magendie. 4to.—*The Academy.*

A Paper was read, "On the Hour Lines of the Ancients." By W. A. Cadell, Esq. F.R.S.

The hour lines on the sundials of the ancient Greeks and Romans correspond to the division of the time between sun-rise and sun-set into twelve equal parts, which was their mode of computing time. An example of these hour lines occurs in an ancient Greek sundial, forming part of the Elgin collection of marbles at the British Museum, and which there is reason to believe had been constructed during the reign of the Antonines. This dial contains the twelve hour lines drawn on two vertical planes, which are inclined to each other at an angle of 106°; the line bisecting that angle having been in the meridian. The hour lines actually traced on the dial consist of such portions only as were requisite for the purpose the dial was intended to serve: and these portions are sensibly straight lines. But the author has shown, in a paper published in the Transactions of the Royal Society of Edinburgh, that if these lines are continued through the whole zone of the rising and setting semidiurnal arcs, they will be found to be curves of double curvature on the sphere. In the present paper the author enters into an investigation of the course of these curves; first selecting as an example the lines indicating the 3rd and the 9th hours of the ancients. These lines are formed by the points of bisection of all the rising and setting semidiurnal arcs; commencing from the southern point where the meridian cuts the horizon, and proceeding till the line reaches to the first of the always apparent parallels, which, being a complete circle, it meets at the end of its first quadrant. At this point the branch of another and similar curve is continuous with it: namely, a curve which in its course bisects another set of semidiurnal arcs, belonging to a place situated on the same parallel of latitude as the first, but distant from it 180° in longitude. Continuing to trace the course of this curve, along its different branches, we find it at last returning into itself, the whole curve being characterized by four points of flexure. If the describing point be considered as the extremity of a radius, it will be found that this radius has described, in its revolution, a conical surface with two opposite

undulations above, and two below the equator. The right section of this cone presents two opposite hyperbolas between asymptotes which cross one another at right angles. This cone varies in its breadth in different positions of the sphere; diminishing as the latitude of the place increases.

The cones to which the other ancient hour lines belong, are of the same description, having undulations alternately above and below the equator; but they differ from one another in the number of the undulations: and some of these require more than one revolution to complete their surface. The properties of the cones and lines thus generated, may be rendered evident by drawing the sections of the cones on the sphere, in perspective, either on a cylindrical or on a plane surface: several examples of which are given in the paper.

January 13, 1831.

JOHN W. LUBBOCK, Esq. V.P. and Treasurer, in the Chair.

The Earl of Selkirk was elected a Fellow of the Society.

The following Presents were received, and thanks ordered for them:—

Zoological Researches, and Illustrations; or Natural History of Non-descript, or imperfectly known, Animals, in a Series of Memoirs. Illustrated by numerous Figures. By John V. Thompson, Esq. Vol. I. Part I. 8vo.—*Presented by the Author.*

The Philosophical Magazine and Annals of Philosophy. By R. Taylor, F.L.S. and R. Phillips, F.R.S. No. 49. 8vo.—*The Editors.*

Notice of the Proceedings of the Astronomical Society. No. 30. 8vo.—*The Society.*

Occultations of Planets and Fixed Stars by the Moon, in the year 1831. Computed for Greenwich by T. Henderson, Esq. 8vo.—*The Astronomical Society.*

The National Portrait Gallery. By Wm. Jerdan, Esq. No. 21. 8vo.—*The Proprietors.*

The Life of Sir Humphry Davy, Bart. LL.D. late President of the Royal Society. By John Ayrton Paris, M.D. F.R.S. 4to.—*The Author.*

An Experimental Enquiry into the Number and Properties of the Primary Colours, and the source of Colour in the Prism. By Walter Crum, Esq. 8vo.—*The Author.*

A Dissertation on the component Parts of an Animal Body. By H W. Dewhurst, Esq. 12mo.—*The Author.*

A Synoptical Table of an improved Nomenclature for the Sutures of the Cranium. By the Same. 4th Ed. 12mo.—*The Author.*

Remarks in Reply to a Pamphlet by Nicholas H. Nicolas, Esq., entitled, "Observations on the State of Historical Literature." By Francis Palgrave, Esq. F.R.S. 8vo.—*The Author.*

Das Verhältniss der chemischen Verwandtschaft zur galvanischen Elektricität, in Versuchen dargestellt. Von N. W. Fischer, M. et Phil. Doct. 8vo.—*The Author.*

The reading of a Paper, entitled, On the Equilibrium of Fluids; and the Figure of a Homogeneous Planet in a Fluid state. By James Ivory, Esq. M.A. F.R.S.—was commenced.

January 20.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, President, in the Chair.

William John Blake, Esq. M.A. was elected a Fellow.

The following Presents were received, and thanks ordered for them:—

Transactions of the Society for the Encouragement of Arts, Manufactures, and Commerce, for the year 1829. 8vo.—*Presented by the Society.*

Proceedings of the Committee of Science and Correspondence of the Zoological Society of London. (Nov. 9, to Dec. 4, 1830.) 8vo.—*The Society.*

On the Probable Connection of Rock Basins, in Form and Situation, with an internal Concretionary Structure in the Rocks on which they occur: introduced by Remarks on the alleged Artificial Origin of those Cavities. By E. W. Brayley, Jun., Esq. 8vo.—*The Author.*

Tabulæ Regiomontanæ Reductionum Observationum Astronomicarum ab Anno 1750 usque ad Annum 1850 computatæ. Auctore F. W. Bessel. 8vo.—*The Author.*

The reading of Mr. Ivory's Paper was resumed and concluded.

The author considers the essential property of a fluid, and that on which its definition should be founded, as consisting in the perfect mobility of its particles among one another. If abstraction be made of the force of gravity, or other accelerating force, when a continuous fluid is at rest, and consequently in a state of equilibrium, all its particles are equally pressed in every direction, are equally distant from one another, and are similarly arranged about every interior point. No fluid is absolutely incompressible; but the degree of compressibility may be conceived to be so small as not to affect the results; and it is accordingly disregarded in the investigations which occupy the present paper.

These investigations are built on the assumption that the hydrostatic pressure at every point of the fluid is the same function of the three rectangular co-ordinates of the point drawn to three planes intersecting one another at right angles. The author shows that the algebraical expressions of the accelerating forces producing the pressure are not entirely arbitrary; because they must necessarily be equal to the partial differential co-efficients of a function of three independent variables, and therefore they are likewise the same func-

tions of the co-ordinates of their point of action in every part of the mass. This is one of the conditions required for the equilibrium of a mass of homogeneous fluid; and a second necessary condition is, that these functions of the ordinates are capable of being integrated. When these two conditions are fulfilled, the determination of the figure of equilibrium is reduced to a question purely mathematical. For we can form an equation expressive of an equilibrium between the accelerating forces and the variation of pressure, and by integrating this equation we may obtain the hydrostatic pressure; whence may be deduced the equation of all those points at which there is no pressure, that is, of the outer surface of the fluid. All that is then requisite for securing the permanence of the figure of the fluid, is that the pressures propagated through the mass be either supported, or mutually balance one another. The upper surface, which is at liberty, and where there is no pressure, and all interior surfaces, where the pressure is constant, have the same differential equation; and from this the author infers that such surfaces are perpendicular to the resultant of the accelerating forces acting upon the particles contained in them. These interior surfaces were denominated by Clairaut *level surfaces;* and they are distinguished by the two properties of being equally pressed at all their points, and of cutting the resultant of the forces at right angles.

The author next extends the investigation to heterogeneous fluids, the different parts of which vary in their density, and deduces a similar conclusion to the former with respect to the perpendicularity of the interior level surfaces to the resultant of the accelerating forces, which act upon the particles situated in each surface respectively. He discusses the hypothesis of Clairaut, of narrow canals traversing the mass in various directions, and shows that the same results follow from it as from the general theory.

The conditions laid down by Clairaut, and all other authors, as those which are necessary for the equilibrium of a homogeneous fluid, are these two:—first, the accelerating forces must be expressed by the partial differential co-efficients of a function of three independent co-ordinates; secondly, the resultant of the forces in action at the upper surface at liberty must be perpendicular to that surface. The author shows that the second condition is a consequence of the first; and he states the independent conditions of equilibrium to be these:—first, the expressions of the forces must be the same functions of the co-ordinates in every part of the mass; secondly, the same expressions must be the partial differential co-efficients of a function of three independent co-ordinates.

In a very extensive class of problems, the difference in the two ways of laying down the conditions of equilibrium disappears. But the theory of Clairaut cannot be extended to the cases in which the particles mutually attract or repel one another, or where the accelerating forces depend on the figure of the mass of fluid. Such is the condition of a homogeneous planet in a fluid state, in which there are forces which prevail in the interior parts, but vanish at the surface; and which are, therefore, not taken into account in Clairaut's theory. But since

these forces tend to change the figure of the fluid, that theory is inadequate to give an exact determination of the equilibrium in those cases.

In the second part of the paper, the author applies his theory of the equilibrium of fluids to the determination of the figure of the planets, under the supposition that they are composed wholly of fluid materials. For this purpose he first considers the problem of determining the equilibrium of a homogeneous mass of fluid entirely at liberty, when the accelerating forces are known functions of the coordinates at their point of action. In the investigation of this problem, he supposes that the centre of gravity is at rest, and undisturbed by the action of any accelerating force. He then supposes the fluid to be in equilibrium, and that three planes are laid down, intersecting one another at right angles in the centre of gravity of the mass, to which planes the particles of the fluid are referred by rectangular co-ordinates. The algebraical consequences of this supposition are then pursued, the conditions necessary to equilibrium pointed out, and the conclusion deduced, that the resultant of the accelerating forces is perpendicular to the outer surface, and also to the interior level surfaces of the fluid, at every point of which there is the same intensity of pressure. The figure of the fluid being determined, it remains to inquire, whether the equilibrium is secure; and the result of the inquiry furnishes an equation which proves that the particles have no tendency to move, from any inequality of pressure.

A further discussion is entered into in order to prove that the pressures propagated from the surfaces into the interior parts balance and destroy one another, which completely establishes the permanence of the figure of the fluid. It is also shown that the mass of fluid, under these circumstances, has no tendency to turn upon an axis.

To illustrate the foregoing problem, the author applies it to the determination of the figure of equilibrium of a homogeneous mass of fluid entirely at liberty, of which the particles attract one another with a force directly proportional to the distance, at the same time that they are urged by a centrifugal force caused by rotation about an axis.

He then enters upon the investigation of the second problem, in which the law of attraction of the particles is that of the inverse duplicate ratio of the distance; and finally arrives at the conclusion, that the form of the fluid in equilibrium is, exclusively of all other figures, an oblate elliptical spheroid of revolution, and that its axis of rotation is the lesser axis of the spheroid. He also shows that within the spheroid there are no more than two sets of surfaces equally pressed by the action of the exterior fluid; and no more than two different spheroids of equilibrium answering to the same rotatory motion. If the whole spheroid be one of small oblateness, the greatest of the interior surfaces of equable pressure, which is not a level surface, stands upon the equator; and the rest are within this, and are similar to it, and similarly posited. When it is very oblate, the greatest of these surfaces is described about the lesser axis; and the rest are within it, and are similar to it, and similarly posited. The existence

of two sets of interior surfaces, that are equally pressed at all their points by the action of the exterior fluid, is inconsistent with Clairaut's theory, and is a proof of the insufficiency of that theory for determining the figure of a homogeneous planet.

January 27.

GEORGE RENNIE, Esq. V.P., in the Chair.

The following Presents were received, and thanks ordered for them:—

Views of the Pelvis, showing the Natural Size, Form and Relations of the Bladder, Rectum, Uterus, &c. in the Infant and in the Adult; taken from Preparations made for the Museum of the Royal College of Surgeons in Ireland. By John Houston, Esq. folio.—*Presented by the Author.*

An Account of two newly discovered Muscles for compressing the Dorsal Vein of the Penis, in Man and other Animals; and also of a similar Provision for compressing the Veins of the Chameleon's Tongue. By the Same. 8vo.—*The Author.*

Connaissance des Tems pour l'An 1833. 8vo.—*The Board of Longitude of France.*

L'Annuaire pour l'An 1831. 12mo.—*The Same.*

Bulletin de la Société Française de Statistique Universelle. Première Livraison. 4to.—*The Society.*

Statuts, et Liste des Membres, de la Société Française de Statistique Universelle. 8vo et folio.—*The Society.*

A paper was read, On the probable electric origin of all the phenomena of Terrestrial Magnetism; with an illustrative experiment. By Peter Barlow, Esq. F.R.S. Corr. Mem. Inst. France, and of the Imp. Acad. St. Petersburgh.

The author begins his paper by a retrospect of the several discoveries on terrestrial magnetism made since the commencement of the present century. Humboldt, by his numerous and accurate observations on this subject, laid the foundation of all the scientific knowledge relating to it, which we hitherto possessed. The task of reducing these observations to definite principles, by subjecting them to calculation, was undertaken by Biot; and the conclusion which he drew from them was, that on the hypothesis of the earth's being a great magnet, the facts would best accord with the supposition that its two poles are coincident, or indefinitely near to each other, at the centre of the globe. The same result was also obtained, though by a different process of reasoning, by M. Kraft of St. Petersburgh. It followed as a necessary consequence, that terrestrial magnetism observes a law different from that of a permanently magnetic body, but identical with that of a body in which transient magnetism is excited by induction. The law which obtains in the case of a sphere of iron rendered magnetic by induction was first investigated, in 1829, by Mr. Barlow; and also, by Mr. Charles Bonnycastle, Professor of

Mathematics in the University of Virginia; it has since been amply confirmed by the more elaborate analytical investigations of Poisson. But the result of all these inquiries, instead of affording us clearer notions of the action of terrestrial magnetism, tended rather to perplex and obscure our views respecting its nature and operation.

While our knowledge was in this imperfect and almost retrograde state, a new light broke in upon us in the great discovery of Oersted, which, by disclosing the intimate relation which electricity bears to magnetism, must be regarded as forming a new era in the history of this department of physical science. The operation of the tangential force between a galvanic wire and a magnetic needle was pointed out by the author, in a paper which was read to the Royal Society in the year 1822; and was still more fully examined by M. Ampère, who extended the investigation to the law of the reciprocal action of galvanic currents on one another; and thence deduced a general theory of magnetic action.

Having established the general fact that the magnetism which is induced on an iron ball resides only on its surface, and acts according to the same laws as the magnetic influence of the earth, the author was desirous of ascertaining whether he could succeed in imitating the effects of terrestrial magnetism by distributing galvanic currents round the surface of an artificial globe. This conjecture he pùt to the test of experiment, by having a hollow wooden globe constructed, sixteen inches in diameter, with grooves cut at all the parallels of latitude distant by 10° from each other. Copper wires were then laid in these grooves, and disposed so as to allow of the transmission of a galvanic current in similar directions through the whole system of these circular wires. This being effected, it was found that a magnetic needle, properly neutralized, so as to be exempt from all influence from the earth, and freely suspended in different situations on the surface of this artificial globe, assumed positions exactly analogous to those of the dipping-needle in different parts of the earth. The author has no doubt that if the electrical currents in this experiment could be increased indefinitely, the apparatus might be made accurately to represent every circumstance of magnetic dip and direction actually observed in nature.

It thus appears that all the phenomena of terrestrial magnetism may be produced by electricity alone: for it is evident, that in place of the needle employed in the experiment above described, the galvanic needle of Ampère might have been substituted, to the complete exclusion of the only magnetic part of the apparatus.

The discovery of Seebeck, that heat applied to a circuit of metallic conductors develops galvanism, and consequently gives rise to magnetic induction, supplies another link in the chain of evidence, that terrestrial magnetism is purely an electrical phenomenon, deriving its origin, during the diurnal revolution of the earth, from the action of the sun's rays on successive portions of its surface, in directions parallel to the equator. The probability, therefore, is now much increased, that magnetism is a quality not essentially distinct from electricity.